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ORIGINAL ARTICLE

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Abstract
Objective Within Germany, a significant decrease in avoidable mortality from ischemic heart disease (IHD) has been observed since the early 1990s. The objective of this paper is to identify the specific reasons that have led to the decrease in the number of avoidable deaths from IHD in West and East Germany from 1996 to 2004.
Methods We analyzed the mortality rate from IHD of the male population aged less than 65 years on the regional level of German counties over the 1996–2004 period. Methodologically, after adjusting for a number of health structure variables, the socioeconomic structure of each region, and yearly time trends in avoidable mortality, we accounted for unobservable differences among regions by using a fixed-effect estimator.
Results Our main result reveals that the number of intracardiac catheter facilities, an important diagnostic tool for IHD, significantly accounts for decreases in avoidable mortality from IHD. This is important, as the modernization of the East German health sector included a considerable catching-up process in the number of IC facilities provided relative to West Germany.
Conclusion Our results suggest that the modernization of the East German health sector may have contributed to saving people from premature deaths.

Keywords Avoidable deaths · Ischemic heart disease · Intracardiac catheters · Germany

Introduction

Improving health system performance can save lives. For example, Nolte and McKee (2008) estimate that a minimum of 75,000 deaths from treatable conditions for those aged under 75 would not have occurred in the USA in 2002 if the US health system had performed at the average level of other industrialized countries. Consequently, identifying causes contributing to health system performance and to improving it is of substantial interest to society. The objective of this paper is to identify specific factors affecting health system performance in Germany in the 1996–2004 period.

With this aim, we measured health system performance by the number of avoidable deaths from ischemic heart disease (IHD) within the male population. IHD, such as angina pectoris or myocardial infarction, is characterized by reduced blood supply to the heart and can be fatal. The concept of avoidable deaths relies on the insight that deaths in younger ages are potentially avoidable if the given medical know-how is exploited (Rutstein et al. 1976; French and Jones 2006). Within the European Union, IHD accounts for 16% of all deaths and for 11% of deaths for those under the age of 65 (Eurostat 2006). In 2004, three out of the top ten most frequent causes of acute care hospitalization were assigned to this disease group, and 167,681 people died from IHD in Germany.

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Since 1990, German reunification has brought about substantial progress for the East German economy relative to the West German economy. As in other parts of the economy, a large amount of funding was aimed at the modernization of the health sector. For example, average annual public investment per bed in East German acute care hospitals—which is the biggest health sector in terms of costs—has been roughly 100% above the level of public investments in West German hospitals since reunification. The improvement of the health structure might have contributed to greater utilization of the health sector. Since reunification, demand in terms of patients treated has increased by 30% in East Germany compared to 20% in West Germany.

There was also a considerable decrease in avoidable deaths, especially in East Germany, whose health sector was heavily modernized. Table 1 shows standardized rates of avoidable mortality from IHD per 100,000 male inhabitants under the age of 65 in East and West Germany from 1996 and 2004. In 1996, the rate was 45.3 in West and 70.9 in East Germany. Until 2004, it dropped considerably and was much faster in East than in West Germany. Still, mortality rates in 2004 were, on average, 11.8 percentage points higher in East than in West Germany. East German levels in 2004 were nearly at the same level as West German levels in 1996.

In Germany, the responsibility for the surveillance of public health and financing of hospital infrastructure is at the level of the German Federal States (Busse and Riesberg 2005). Due to differences in health policies across Federal States and especially between East and West Germany, the density and provision of health services differ largely across them. We used these differences to measure how differences in health infrastructure between East and West Germany are related to decreases in avoidable mortality over time.

In view of this continuing East-West divide in health system performance, it is unclear to what extent policies to improve the health structure have been successful or not. The literature has identified numerous explanations for the regional variation in the occurrence of ischemic heart disease, such as nutrition, physical activities, smoking and alcohol consumption, socioeconomic factors, and differences in the medical health structures (Bobak and Marmot 1996; Kroumhout 2001; Wübker 2007). Our focus is on the impact of specific indicators of health infrastructure. The identification strategy assumes that there are three sources of geographical variability in health system performance over time: differences in socioeconomic characteristics, random variability, and differences arising from the availability of local health structure. Once the model accounts for the first two sources, the variability in avoidable deaths can be attributed to differences in health structure, such as the hospital market structure or specific structural indicators for the treatment of IHD. Further, unobservable differences across regions, such as lifestyle, may impact upon health outcomes. Ignoring these factors may distort the estimated effects obtained from a classical ordinary least squares estimator. Methodologically, we accounted for unobservable differences among regions by exploiting the panel structure of our data by using fixed-effect estimators.

The paper is organized as follows: the data and descriptive results are presented, followed by an introduction of the econometric model, results and conclusion.

Table 1 Standardized rates in avoidable deaths from ischemic heart disease within the male population per 100,000 male inhabitants

	Total	West Germany	East Germany	East-West difference
1996	49.8	45.3	70.9	25.6
2004	33.4	31.4	43.2	11.8
Change in avoidable deaths since 1996	−16.4	−13.9	−27.7	−13.8

Causes of Deaths Statistic 1996 and 2004, own calculations

Data

We analyzed the mortality rate from IHD of the male population aged less than 65 years on the regional level of German counties over the 1996–2004 period. The group of ischemic heart disease is defined in the 10th revision of the International Classification of Diseases (ICD) by the codes I20 to I25. These cover angina pectoris (I20), initial (I21), subsequent (I22), and recidivating myocardial infarctions (I23), and other acute (I24) and chronic ischemic heart diseases (I25). Data in 1996 and 1997 were codified according to the 9th revision of ICD by the codes 410 to 414. Data before 1996 are unreliable or unavailable, so that it is not possible to retrace the modernization of health infrastructure back to German reunification in 1990. Mortality rates are standardized by dividing actual values by the expected equivalent as defined by national average mortality rates in the age groups 1 to 4 years, 5 to 9 years, etc., up to 60 to 64 years. The data were extracted from the Causes of Deaths Statistic (*Todesursachenstatistik*), which provides the individual cause and year of death, age, sex, and county of residence.

Explanatory variables, as described below, have been merged from the following sources: the annual German Hospital Statistics, which include data of all hospital inpatients from all hospitals in Germany; the Regional Data

Statistics providing information on socioeconomic variables; Bruckenberger's (2007) information on structural indicators for the treatment of IHD. Because of missing data for some of the years for Mecklenburg-Vorpommern and Schleswig-Holstein, the analysis is based on 3,853 observations from 439 counties in 16 Federal States, out of which 1,006 observations from 118 counties in 5 States are for East Germany, and 2,847 observations from 321 counties in 11 states are for West Germany. Because of its very similar health infrastructure, Berlin was counted in the West German subsample.

We used three broad categories of explanatory variables, which are supposed to account for the variation in avoidable deaths: specific structural indicators for the treatment of IHD, the hospital market structure, and socioeconomic variables.

First, we considered the number of intracardiac catheter (IC) facilities and the number of percutaneous transluminal coronary angioplasties (PTCA) as specific structural indicators for the diagnosis and treatment of IHD. IC facilities offer IC examinations. These are minimally invasive procedures involving the insertion of a catheter into a coronary artery to test for an abnormal narrowing of the coronary vessels. PTCA is a therapy used for the widening of a narrowed blood vessel with the means of balloons that are passed into the narrowed spaces and then inflated. Medical evidence points out the merits of these structural indicators for the success in the diagnosis and treatment of IHD (Bruckenberger 2007; Van de Werf et al. 2003).

Second, the treatment of IHD is closely linked to the acute care hospital sector because of the emergent and initially high level of intensity of care required, which is provided by acute care hospitals. We approximated for the structural quality of acute hospital care by several measures. First, we measured the density of the provision of acute care services as approximated by the ratio of the number of beds to the number of residents at county level. Second, we considered the medical staff-to-patient ratio, which has been shown to be a potential determinant of the quality of care in hospitals. For a discussion of the topic and an application, see Evans and Kim (2006). We used the ratio of the number of patients to full-time doctoral staff as a proxy for the quality of the intensity of treatment. Third, we considered the number of large medical devices available in acute care hospitals per million inhabitants. The devices included are: digital substraction-angiography devices, gamma cameras, heart–lung machines, and computer tomographs. The data are extracted from the German hospital statistics (*Krankenhausstatistik*).

Fourth, we considered the level of market concentration, as measured by the Herfindahl-Hirschman Index (HHI). The HHI is defined as the sum of the squared market shares of all hospitals in the hospital's *i* market. The hospital's local market is defined as the sum of beds within a maximum distance of 50 km. High values of the index reflect high levels of market concentration. These have been shown theoretically and empirically to decrease the quality of care in markets with fixed prices such as the German hospital market (Gaynor 2006). Fifth, theoretical research predicts that quality of acute care hospital services may be related to the ownership type of the providers (Hansmann 1980; Weisbrod 1988). For a discussion of the distinguishing features of ownership types, see Sloan (2000). However, in the US context these predictions have mostly not been fulfilled (Sloan et al. 2001). Regarding cardiac treatment, recent results from Taiwan (Lien et al. 2008) suggest that patients admitted to non-profit hospitals received better quality care, as measured by 1- and 12-month mortality rates. To test for the relevance of ownership in the German context, we controlled for the regional market shares in beds by the ownership type of hospitals: public, private for-profit, or private non-profit. Finally, we also controlled for the market share of university hospitals because of their specific role as centers of medical excellence.

The HHI, the market shares by ownership type, the market share of university hospitals, and bed density are potentially endogenous to unobserved hospital quality and patient characteristics. Therefore, the estimated effects of these variables on avoidable deaths may be biased. As a possible solution, Kessler and McClellan (2000) propose an identification strategy that bases the measures of hospital market structure on an exogenous source of variation: travel distances between hospitals and patients. In short, Kessler and McClellan specify patient-level hospital choice models and predict the number of patients admitted to each hospital based solely on exogenous characteristics of patients and hospitals. The predicted numbers of patients for each hospital are then used to calculate measures of hospital market shares and market concentration in each geographical region. The effects of these measures on the dependent variable are unbiased, because they do not depend on unobserved patient and hospital characteristics. For a detailed description of the model, see Kessler and McClellan (2000). We adopted Kessler and McClellan's approach to obtain unbiased effects of these variables on avoidable mortality.

Finally, regional variability in the socioeconomic structure is meant to account for differences in the risk factors that impact upon rates in avoidable mortality. Risk factors will determine the needs of the population to utilize health care services (Carr-Hill et al. 1994). The literature on socioeconomic status and health has identified many determinants of health, although evidence on the relevance of each of the factors varies in each study (see Cutler et al.

Table 2 Intracardiac catheter facilities and PTCA in East and West Germany per million inhabitants, 1996–2004

	Intracardiac catheter facilities			
	Total	West Germany	East Germany	East-West difference
1996	4.46	5.33	2.53	−2.80
2004	7.55	8.21	6.09	−2.12
Absolute change in IC facilities since 1996	3.09	2.88	3.56	0.68
	Percutaneous transluminal coronary angioplasties			
	Total	West Germany	East Germany	East-West difference
1996	1446.9	1719.8	846.6	−873.2
2004	3263.1	3468.5	2811.2	−657.3
Absolute change in PTCAs since 1996	1816.2	1748.7	1964.6	215.9

Own calculations

2008 for an overview). We used average levels of income per capita, the proportion of the population without educational attainment, and the unemployment rate as an approximation for the socioeconomic structure at the county level. These three factors are widely identified as important determinants of health (compare Cutler et al. 2008). Further, we included a measure of the degree of rurality of each county to account for unobserved heterogeneity across counties, which may reflect differences in household structures, lifestyle, and health behavior (Hauck and Street 2006). Finally, we considered the ratio of hospital visits to inhabitants from the same county of origin as a proxy for unobservable heterogeneity in health status. Health utilization and health status have been shown to be strongly correlated (van Doorslaer and Koolman 2002). However, this is at best only a partial indicator of health status, because we failed to observe the extent of ambulatory care. Table A1 in the Appendix presents the descriptive statistics.

As mentioned above, the literature reveals that the availability of heart catheterization technology is important to avoid premature deaths. Table 2 shows a considerable catching-up process in IC facilities and PTCA in East versus West Germany during the period considered. The difference in the number of IC facilities and PTCA per million inhabitants between East and West Germany shrank considerably despite a substantial increase in both IC facilities and PTCA in West Germany.

Table 3 shows how our structural indicators changed by quartiles of the regional changes in avoidable mortality

Table 3 Changes in explanatory variables by quartiles of decreases in average avoidable mortality in German counties, 1996–2004

	1st Quartile		2nd Quartile		3rd Quartile		4th Quartile	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Avoidable deaths	−45.1	13.8	−23.5	3.4	−11.7	3.3	4.6	8.5
Structural indicators for treatment of IHD								
PTCA	4382.2	1322.9	3870.5	1053.5	3616.2	975.9	3306.5	753.7
IC facilities	3.1	0.9	2.6	0.6	2.4	0.8	2.0	0.8
Hospital market characteristics								
Market concentration	108.2	2788.1	−351.7	1715.5	−267.2	2010.4	−326.0	1971.8
Share of hospitals, in percent								
Public	−2.7	3.1	−0.9	2.9	1.2	3.3	3.8	3.1
Nonprofit	2.2	16.7	1.8	16.4	−2.0	18.0	−2.5	22.6
University	0.5	15.1	−0.4	13.9	0.8	16.0	−1.3	13.1
For-profit	1.9	24.4	0.4	20.3	1.9	27.0	1.1	25.1
Bed density(*1000)	2.6	1.6	3.7	1.1	4.6	8.5	3.8	10.0
Doctor-to-patient ratio(*1000)	0.4	3.2	0.2	3.3	0.2	3.9	0.6	1.8
Large medical devices(*1000)	0.2	0.4	0.3	0.5	0.2	0.4	0.2	0.4

The number of available counties is 439

over the 1996–2004 period and previews the results from the regression models. After an ordering of the observations from lowest to highest values, quartiles divide the sample into four equally spanned intervals, each containing 25% of observations. In Table 3, the quartiles are sorted by decreasing improvements in average mortality rates, i.e., the 1st (4th) quartile presents counties with the highest (lowest) decrease in mortality rates over 1996–2004. Higher increases in the number of PTCA and IC facilities are associated with higher decreases in avoidable mortality. For example, PTCA increased in the quartile with the highest reduction in mortality more (4,482) than in the quarter with the lowest reduction in mortality (3,306). This is consistent with the medical evidence of the importance of these indicators for a successful diagnosis and treatment of IHD. Contrary to expectations, counties with an increasing market concentration have higher decreases in the mortality rate. Decreases in the shares of public hospitals and increases in the share of non-profit hospitals go along with decreases in the mortality rate. There is no clear association between changes in the shares of for-profit and university hospitals and the mortality rate. The same is true for the relation of changes in bed density, doctor-to-patient ratios, and large medical devices to changes in the mortality rate.

Methods

The clustering of repeated annual observations within counties implies a panel structure of the data. In general, the pooled regression, the fixed effects method, or the random effects method can be applied to panel data (Wooldridge 2002). The pooled regression assumes that over time individual observations are independent of each other. This is clearly not valid in our case, as geographical units are changing over time depending on their historically inherited characteristics, such that individual observations are correlated over time. Therefore, applying a pooled regression to our data would have been inappropriate.

To account for the correlation, a specific variable had to be introduced to the regression equation for each geographical unit. This prevented the unobserved Federal State specific heterogeneousness from being assigned to other explanatory variables, which would have distorted them. Both the random and the fixed effects methods were dealt with in this way. Within the fixed effects method, a dummy variable was introduced for each geographical unit. The advantage of this approach was that no assumptions needed to be made regarding the distribution of the dummy variables.

Within the random effects method, heterogeneousness was established by additional interference terms for each geographical unit with a predicted mean value of zero. This suggests that the interference terms did not correlate with the explanatory variables and therefore were random. These assumptions would have been rather unrealistic in our case. For instance, lifestyle differences among geographical units are systematic and not random. The Hausman test serves as a formal test of the appropriateness of the fixed versus the random effects model.

To exploit the panel structure of the data, we define the following fixed-effect model:

$$y_{it} = \alpha_i + \beta' x_{it} + t_{1997} + \ldots + t_{2004} + \varepsilon_{it}, \quad i = 1, \ldots, N,$$

where y_{jt} is the ratio of avoidable deaths in the tth year within the ith county, α_i is a county-specific component capturing unobserved time-constant heterogeneity across counties, x_{it} is a set of observed variables associated with the counties' ratios of avoidable deaths, t_{1997} to t_{2004} are yearly dummies, and ε_{it} is a time- and county-specific error term. Finally, βs are coefficient estimates. All variables are centered around zero by subtracting their grand mean from the values of each region. After centering, the constant can be interpreted as the mean intercept across all years in all counties in all Federal States.

Results

The random effects specification was rejected by the conventional Hausman test. We therefore present the results of the fixed-effects model including all explanatory variables. Table 4 shows estimates for the whole of Germany, as well as separate results for West and East Germany.

Increases in the number of IC facilities are highly statistically significant and related to a decrease in regional mortality rates. An additional IC facility per million inhabitants contributes to a reduction in avoidable mortality by 1.43 years. The effect is higher in East than West Germany, although it is significant in the East only on a low significance level. In contrast, PTCA is not significantly related to changes in mortality on conventional statistical levels.

Within-county changes of the measures of the structure of the acute care hospital market are not significantly related to changes in avoidable deaths. Similarly, within-county changes in most of the socioeconomic variables are not significantly associated with changes in the dependent variable. Only the increasing degree of rurality is negatively associated with mortality in West Germany, but positively in East Germany. This may reflect pronounced changes in the rural socioeconomic structure in East versus West Germany. Further, increases in the hospitalization rate in

Table 4 Determinants of avoidable deaths from ischemic heart diseases in East versus West Germany

	Germany		West Germany		East Germany	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
Structural indicators for treatment of IHD						
IC facilities	−1.43***	(0.15)	−1.95***	(0.67)	−2.50*	(1.48)
PTCA*1000	−3.91	(30.2)	−2.01	(2.03)	−1.01	(2.03)
Structure of acute care hospital market						
Market						
Concentration*1000	−1.02	(2.03)	2.02	(2.13)	2.14	(4.21)
Share of hospital beds						
For-profit	−0.06	(2.01)	−2.02	(2.43)	−0.45	(4.10)
Public	0.69	(1.62)	−0.11	(1.85)	−1.62	(3.62)
University	2.65	(2.27)	1.54	(2.81)	2.62	(4.43)
Bed density (*100)	4.11	(2.78)	−0.64	(3.69)	6.89	(4.66)
Doctor-to-patient ratio	−18.19	(30.93)	28.96	(39.62)	−39.74	(53.26)
Large medical devices (*1000)	−8.29	(8.42)	−5.70	(4.09)	0.97	(2.23)
Socioeconomic variables						
Increasing rurality	2.20	(1.68)	−1.75	(1.84)	13.42***	(3.45)
Income per capita*1000	0.05	(1.02)	−0.11	(1.02)	3.02	(2.01)
Unemployment rate	−0.23	(0.37)	−0.32	(0.48)	−0.48	(0.377)
No school graduation	−14.83	(12.79)	7.59	(15.82)	−2.19	(25.68)
Hospitalization rate	−20.96	(19.52)	−68.26***	(22.67)	48.06	(39.12)
Year						
1997	1.06	(0.90)	0.29	(0.98)	−7.14***	(2.41)
1998	0.95	(1.13)	−1.03	(1.15)	−13.18***	(3.29)
1999	0.01	(1.36)	−2.71*	(1.47)	−17.68***	(4.35)
2000	−1.88	(1.56)	−4.37**	(1.96)	−24.12***	(4.77)
2001	−1.94	(1.75)	−4.91**	(2.36)	−25.24***	(5.26)
2002	−3.85**	(1.87)	−6.20***	(2.35)	−30.87***	(5.82)
2003	−2.84	(1.99)	−6.04**	(2.43)	−28.48***	(6.66)
2004	−2.75	(2.36)	−6.50**	(2.88)	−30.67***	(8.17)
Constant	55.52***	(2.79)	52.63***	(2.63)	80.33***	(4.92)

Number of observations is 3,853

***Significant at the 1% level; **significant at the 5% level; significant at the 10% level

West Germany are related to decreases in mortality, whereas there is no significant effect for East Germany.

The yearly dummies are highly statistically significant in the separate West and East regressions, signaling a clear pattern of decreasing mortality over time from IHD in the male population. These decreases are stronger in East than West Germany and capture nearly all of the reduction in avoidable deaths in the given time period. For example, the 2004 year dummy finds that with respect to the base year, 1996, avoidable mortality was reduced by 30 cases per 100,000 inhabitants in East Germany and 6.5 cases in West Germany. The time trends may be related to pronounced changes in lifestyle, socioeconomic environment, and other coronary risk factors in East Germany.[1] However, unfortunately we were not able to test these hypotheses with the current data set.

Discussion and conclusion

The objective of this paper was to identify selected forces of health system performance in Germany over the period 1996–2004 as measured by the reduction of the number of

[1] See Müller-Nordhorn et al. (2004) for a good overview of the literature.

avoidable deaths from ischemic heart disease (IHD) within the male population. Methodologically, after adjusting for the socioeconomic structure of each region and yearly time trends in avoidable mortality, we have accounted for unobservable differences between regions by the use of a fixed-effect estimator.

Our main result reveals that the number of intracardiac catheter facilities, which are an important diagnostic tool for IHD, account for decreases in avoidable mortality from IHD. This is important as the modernization of the East German health sector has included a considerable catching-up process in the number of IC facilities provided in East as compared to West Germany. Our results suggest that this modernization may have contributed to saving people from premature deaths. As a consequence, investments in the set-up and modernization of intracardiac catheter facilities seem warranted in general. However, gains in quality and years of life have to be compared to the costs of set-up and maintenance of these facilities. Except for the intracardiac catheter facilities, we could not identify any structural factors of health system performance that would relate significantly to reductions in avoidable deaths.

Further, decreases in both West and East German mortality rates are ‘explainable’ to a large degree by unobservable factors such as yearly dummies. It is therefore probable that other factors not accounted for in this study (e.g., risk factors) might be more important for reductions in mortality. Unfortunately, this hypothesis was not testable with our data set.

Moreover, the time trends clearly show a stronger decrease in avoidable deaths in East than in West Germany. The initial level of avoidable deaths in 1996 was much higher in the East than in the West. A reduction from this high level may be less costly with a given medical knowledge that was already available in West Germany at this time. Still, the decrease was not high enough to close the gap between West and East German levels in avoidable deaths. It may be that the impact of health infrastructure on reductions in avoidable deaths is age specific. Before the modernization of the health system, older age groups in East Germany probably had a high risk of dying before the age of 65. This risk can not be totally reduced by better access to medical care, because convalescence in advanced age is more difficult. Also, older age groups make up a larger proportion in avoidable deaths than younger age groups. This divergence in the relative responsiveness of age groups to the modernization of the infrastructure in East Germany might explain why the divide in East-West rates of avoidable deaths still persists. An age-specific analysis in avoidable deaths in future research should be able to shed light on this hypothesis.

The results of our study may be limited by several aspects. First, the causes of death statistic is, as with most administrative data sets, not primarily collected for the purpose of scientific analysis and may have standard quality deficiencies, as discussed in the literature (Tunstall-Pedoe et al. 1999; Perleth et al. 1999). For example, the autopsy rate is quite low. However, the WHO MONICA (Multinational Monitoring of Trends and Determinants in Cardiovascular Disease) project analysis supported the validity of official mortality rates from ischemic heart diseases that were reported in the cause of death statistic. In addition, since no international comparison was performed here, the data should be quite homogenous with respect to data collection methods across geographical units, such that systematic distortion should be of minor importance. Second, it was not possible to obtain data of all medical areas dealing with ischemic heart diseases, such as information on primary and secondary prevention, risk factors, bypass surgery, and the timing of the treatment (for the relevance of these factors, compare Müller-Nordhorn 2005). We tried to account for this deficiency by applying the fixed effects method, which takes account of all unobservable time invariant factors. As shown in Table 2, health catheterization technology (i.e., PTCA, IC) has spread significantly in the period under observation. Instead, we found only small changes in the provision of bypass surgery in the investigated time span (Bruckenberger 2007).[2] Furthermore, the results suggest that other important areas of ischemic heart disease care, such as primary and secondary prevention or pre-hospitalization time, have changed little in the period under observation (Euroaspire Study Group 1997; Müller-Nordhorn 2005). To sum up, we believe that neglecting these variables should not have distorted our results.

In conclusion, while we could show that an inverse relationship between heart catheterization technology and avoidable mortality from ischemic heart disease exists in both East and West Germany, we do not know why the gap between East and West Germany still remains. Further studies of the causes of this mortality gap between East and West Germany could elaborate on our findings and provide additional insights, which may, for example, lead to improved preventive strategies and more efficient allocation of health resources.

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[2] For example, the number of bypass surgeries rose slightly from 1,210 bypass surgeries per 100,000 inhabitants in 1996 to 1,310 bypass surgeries per 100,000 inhabitants in 2004.

Appendix

Table A1. Descriptive statistics, averages over 1996–2004

Variables	Definition	Mean	SD
Outcome			
Avoidable deaths from IHD	Ratio of deaths from ischemic heart diseases of the male population with age lower than 65 years to the expected equivalent of 100,000 inhabitants given the age/sex profiles and national averages	41.26	23.12
Hospital market structure			
Share of nonprofit hospitals	Market share of the number of beds of private non-profit hospitals	0.31	0.27
Share of for-profit hospitals	Market share of the number of beds of for-profit hospitals	0.08	0.19
Share of university hospitals	Market share of the number of beds of university hospitals	0.16	0.21
Market concentration	Herfindahl-Hirschman Index of market concentration	3,686.71	2,759.77
Bed density	Ratio of the number of beds to the number of residents	2.46 E-03	2.11 E-03
Doctor-to-patient ratio	Ratio of the number of in-hospital patients to full-time doctoral staff	2.35 E-03	0.01
Large medical devices	Ratio of the number of large medical devices including digital substraction-angiography devices, gamma cameras, heart-lung machines, and computer tomographs to 1 million residents	66.12	52.31
Specific indicators for the treatment of ischemic heart diseases			
IC	Ratio of intracardiac catheters facilities to 1 Mio. residents	5.75	2.10
PTCA	Ratio of the number of percutaneous transluminal coronary angioplasties (PTCA) to 1 million residents	2,011.02	746.59
Socioeconomic structure			
Rurality	Degree of rurality from 0 to 1	0.27	0.26
Income	Real per capital income in €	15,223.28	1,987.64
Education	Share of population without school graduation	0.09	0.03
Unemployment	Unemployment rate	11.29	4.55
Hospitalization	Ratio of the number of patients to the number of residents within the same county	0.21	0.03

Notes: Own calculations.

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